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Agricultural Research

The Future of Agricultural Research Programs

"Food production will have to double within the next 40 years to feed the growing world population," a United Nations report warns. From this basic premise, *Cooperative Farmer* magazine questioned four leaders in the field of agricultural research to find out: "Where are the new ideas?" Anson R. Bertrand, director of science and education, represented USDA on the panel. The following is excerpted from his remarks:

Cooperative Farmer: How would you change the focus of today's ag research programs?

Bertrand: We need, as a beginning, to reemphasize fundamental research on basic biological processes—on the mechanisms and functions of living cells. We have had vigorous programs in such basic research before, but our successes perhaps have worked against us.

We had a "revolution" in food production, and as a result there was a feeling that research had just about run its course. Or, put another way, we can feed ourselves and the world, so why go any further? We, indeed, need to get back to the basics in agricultural research.

Crop science is a case in point. We know that to increase plant production we must develop varieties that make more efficient use of photosynthesis. To produce such plants requires knowledge we are starting to acquire, but in some cases we don't have.

Overall, I see the need to refocus agricultural research on the total ecological system so we can identify and evaluate future alternatives for agriculture in a changing world.

Cooperative Farmer: What do you see as the three areas of highest priority in agricultural research during the 1980's?

Bertrand: I see a number of priorities in agricultural research. At the forefront are at least five priorities: increasing agricultural production, achieving energy self-sufficiency, improving our knowledge of human nutrition and its influence on agriculture, saving and restoring renewable natural resources, and rebuilding basic research.

Ranking areas of research according to their long-range priorities can be a risky proposition because we face changing economic and social concerns. Our research is done in the public domain and one item of research may be terribly important to some people and another research endeavor may hold promise for other users. We cannot lose sight of the fact that research that is now off in the corner, so to speak, may lead to findings that warrant a new priority tomorrow.

Cooperative Farmer: What recent work in agricultural research has impressed you with holding the most promise for the future?

Bertrand: Our research work in the priorities I mentioned certainly holds promise for an agriculture of ever-improving efficiency. Here are a few specific examples within these priorities and other research activities:

- We now have a new technique for transferring resistances in wild crop species to domestic plants. That is now being further developed in selected cotton plants.
- Our scientists are studying the transfer of disease and pest resistances in other crops.
- Our scientists have been able to breed an alfalfa strain that has a 70 percent increase in nitrogen. We see other possibilities of improving nitrogen fixation not only in legumes, but incorporating the fixation ability into other crops.
- Cotton farmers, using integrated pest management techniques in a Mississippi program, report a net savings of about $32 per acre on insecticide applications. In one Mississippi county, farmers are seeing yields running an average 50 pounds more lint cotton per acre than for those not in the program.
- On solar heating, the real test will be outside the Sun Belt, and we expect solar power to replace 30 percent of the fossil fuels now being burned to heat livestock shelters on a number of farms in cold-weather states. We have research at work on adapting solar technologies to farms in the Southern and Mid-Atlantic states.
- We have found a strikingly new potential for using genetics to increase the productivity of meat animals. Our findings show that genetically the number of calves, lambs and pigs, for example, can be doubled, and carcass meat yield can be increased through reduced fat to lean ratios.
- On non-point pollution control, our scientists have developed a new computerized system that should be able to forecast what will happen on a farm or in a watershed—and, therefore, should control soil runoff. Our preliminary work in the field appears promising.

Cooperative Farmer: "We've had an extraordinary revolution in American food production, but in the future we can't count on that," claims one business-research organization. Do you agree with this assessment?

Bertrand: Certainly, we no longer expect the kind of great annual yield increases produced during the 1950's and 60's. You can plot yield rates against land or farm labor or energy costs or virtually any other yardstick, and you will find that our agricultural productivity curve is in fact plateauing. At the same time, human numbers are continuing to increase dramatically throughout the world, and so are their needs and expectations.

Our concern is that agriculture, overall, does not have access to a wide base of scientific knowledge today to increase significantly the efficiency of our food and fiber production. We have, in simple language, used up that scientific resource without renewing it as fully as we should have, for various reasons. It will take new and inspired research—often long-term—to find the answers to get agriculture off the productivity plateau.

On an immediate note, we are developing and applying scientific techniques that will help to take some of the slack out of the productivity rate.

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Editor: Patricia Loudon
Assistant Editor: Michael A. Meliker
Photography Editor: Robert C. Bjork
Art Director: Deborah Shelton

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Magazine inquiries should be addressed to: The Editor, SEA Information Staff, Room 3139-S, USDA, Washington, D.C. 20250. Telephone: (202) 447-6133.

Bob S. Bergland, Secretary
U.S. Department of Agriculture

Anson R. Bertrand, Director of Science and Education

Terry B. Kinney, Jr.
Administrator
Agricultural Research

Photo p.8 courtesy
Grant Heilman.

Cover: Nearly 17 of the 42 million pounds of live weight catfish processed by industry in 1979 was waste material. Through aquaculture research, SEA scientists have developed a liquifying process to turn the waste into profitable byproducts. Our article begins on page 10 (067-3-15).

Above: Home economist Sheryl Cottrell checks prescribed sugar and calorie levels in meals prepared twice daily for study participants. With these meals, scientists control sugar intake to study chemical reactions in blood and regulate calorie intake to maintain pre-study weights (0480W329-33.)

Right: Radioactive counter, operated by project coordinator Sheldon Reiser, processes data on blood serum insulin levels. Reiser suggests that blood-insulin tests could be used to identify carbohydrate-sensitive individuals (0780X761-17).

Opposite page: Blood triglyceride levels in both men and women increased as the amount of sugar in their diets increased, but the increases were much greater in men than in women. Spectrophotometer readout graphs data on blood triglyceride levels for Mary Bickard, biochemist at the Carbohydrate Nutrition Laboratory (0780X763-7A).

High-Sugar Diets Risky for Carbohydrate-Sensitive People

Different people respond differently to the sugar they eat. Those with carbohydrate sensitivity—a metabolic disorder —could be risking their health if they consume too much sugar.

This conclusion was made from a study of 24 carbohydrate-sensitive volunteers at the Beltsville Human Nutrition Research Center (BHNRC) at Beltsville, Md. The study was conducted by SEA and the University of Maryland, and coordinated by Sheldon Reiser, BHNRC carbohydrate laboratory chief.

Carbohydrate-sensitive individuals may have several exaggerated metabolic responses to sugar in their diet. One of the most common and noticeable responses is an exceptionally high level of blood triglycerides accompanying a diet high in sucrose (table sugar). A high sugar diet also seems to raise blood cholesterol levels in carbohydrate-sensitive men.

Experiment

The 24 volunteers participating in the research ate formulated diets providing either 5, 18, or 33 percent of total calories in the form of sucrose. A 5-percent sugar diet is far below the average amount of sugar in American diets and would be difficult to maintain in a self-selected diet; an 18-percent sugar diet is near the estimated U.S. average; and a 33-percent sugar diet is above the U.S. average, but does not exceed the intake of many individuals who like sweets.

Each participant maintained diets at each sugar level for 6 weeks. Analyses of blood samples showed that an increase of sugar in the diet was accompanied by changes in several components in the blood. The most significant were increased levels of cholesterol, triglycerides, insulin, glucose, and uric acid.

Cholesterol

Many medical scientists regard factors that increase blood cholesterol levels as undersirable because evidence shows that blood cholesterol promotes development of atherosclerosis. In this disease, deposits (plaques) build up on the inner surfaces of arteries, spreading and thickening to such an extent that they interfere with the ability of the arterial system to deliver needed blood. Also, blood clots may form in reaction to the roughened surfaces of plaques. If a blood clot forms in a location that stops blood flow to the heart or brain, a heart attack or stroke follows. The lipid in highest concentration in atherosclerotic plaques is cholesterol.

The unit of measurement used to express blood levels of cholesterol is milligrams of cholesterol per 100 milliliters of serum (mg/100 ml). In lay terminology, the metric terms are often not expressed—a blood level of 200 milligrams of cholesterol per 100 milliliters of serum is stated as a cholesterol level of 200. There is no unanimous agreement on how high a blood cholesterol level should be before it becomes a health concern. A level of 240 is often considered the break point between normal and abnormal, and many scientists and physicians believe the goal should be levels less than 200. Others believe individuals have different "normal" levels, and that even relatively small increases above this normal (5 to 10 mg/100 ml) are associated with an increased cardiovascular risk.

The mean pre-test total cholesterol level of men participating in the study was 217, which is higher than ideal, but not higher than expected in a group of carbohydrate-sensitive men. The mean pre-test level of women was 175. This sex difference in cholesterol levels was expected. The mean levels for men on the 18- and 33-percent sugar diets were slightly lower than pre-test, and women's levels were higher.

The most significant response to diet was the drop in the cholesterol level of men on the 5-percent sugar diet—the mean was 168.

Mean total cholesterol levels were:

	Pre-test	5-percent sugar	18-percent sugar	33-percent sugar
Males	217	168	207	216
Females	175	166	184	187

Cholesterol and other lipids are not soluble in water and therefore cannot get into blood until they combine with certain proteins to form lipoproteins, which are soluble.

Lipoproteins are often classified according to density. Two of the groups,

low-density lipoproteins (LDL's) and high-density lipoproteins (HDL's), are of special interest to scientists studying the role of cholesterol in heart disease. Experimental evidence indicates that cholesterol in the form of HDL actually decreases the risk of heart disease, while LDL increases the risk.

In current nutrition research, there is special interest in the ratio of LDL to HDL because the ratio seems to be more important than actual levels. Many scientists say a diet that causes an increase in HDL, relative to LDL, reduces the risk of heart disease.

In the study, the two diets highest in sugar caused an undesirable shift in the LDL-HDL ratio of men.

Triglycerides

Triglycerides do not have cholesterol's widespread reputation as a contributing factor in development of atherosclerosis, but some scientists think such a reputation is deserved. Cholesterol is the lipid in highest concentration in atherosclerotic plaques, but triglycerides also are important in plaque makeup.

There is no absolute definition of an abnormal triglyceride level; some guidlines suggest that medical attention is indicated if the level exceeds 150 mg/100 ml in patients under 55.

In the study at Beltsville, there was a large sex difference in response of triglycerides to levels of sugar in the diet. Women's levels were well within the normal range throughout the study, although levels did increase somewhat as sugar levels increased. Triglyceride levels in men increased dramatically as sugar levels increased. Mean triglyceride levels in men on the three levels of dietary sugar were:

Sugar	Triglycerides
5 percent of calories	129mg/100ml
18 percent of calories	169mg/100ml
33 percent of calories	237mg/100ml

Glucose and Insulin

Some components of blood are best considered from the perspective of their *interaction* rather than individual action. The glucose-insulin interaction is an example.

Carbohydrate foods such as sucrose and cereal starches contain glucose but most of the glucose is not in the form of free molecules. Sucrose is a 2-molecule sugar—one is glucose and the other fructose. Huge numbers of glucose molecules are clustered to make complex cereal starch molecules. After carbohydrate foods are eaten, digestive enzymes break them down and free glucose molecules are an end product. The individual molecules can then pass through intestinal walls and enter the blood.

The digestive breakdown is much faster for simple sugar molecules than for complex starch molecules. As a result, the glucose from a high-sugar meal gets into blood much more quickly than does the same amount of glucose from a high-starch meal. An increase of glucose in the blood is a signal to the pancreas to step up production of insulin. A sudden surge of glucose into the blood stimulates a corresponding increase in insulin.

In normal metabolism, insulin efficiently lowers blood glucose levels by helping glucose molecules enter cells, where they become a source of energy. However, if the passage of glucose from blood into cells is slowed down, blood levels remain high and the pancreas reacts by keeping insulin levels high.

In one of the tests given to indicate ability to metabolize sugar, the individual drinks a sucrose solution (2 g sucrose/kg body weight), and blood samples are drawn after 0, ½, 1, 2, and 3 hours and analyzed for glucose or insulin, or both. Blood levels of glucose and insulin both peak after about 1 hour, and in people with normal metabolism the levels are back to pre-test levels after 3 hours. An exceptionally high peak, or failure to return to pre-test levels after 3 hours, are responses characteristic of diabetes patients.

Responses to the test by the 24 study participants were much lower when they were on the diet lowest in sugar, compared to when they were on the two diets higher in sugar:

—When they were on the 33-percent sugar diet, 15 of the 24 had responses resembling those of diabetics or borderline diabetics.

—When they were on the 18-percent sugar diet, 12 of the 24 had this type of response.

—When they were on the 5-percent sugar diet, only 4 of the 24 had this type of response.

Elevated insulin response to a high-sugar meal is one of the earliest symptoms of maturity-onset diabetes. Evidence linking elevated insulin levels with heart disease has been reported. Also, insulin is highly lipogenic; it stimulates synthesis of lipids in the body.

Uric Acid

Uric acid is best known for its association with gout. The pain suffered by gout patients is caused by uric acid crystallizing in inflamed joints.

Patients with heart disease have higher than average uric acid blood levels. Persons in a pre-diabetic state also have elevated uric acid levels, but it drops after development of overt diabetes. Because uric acid is associated with heart disease and diabetes in these ways, it is suspected of having a role in causing these diseases. However, a mode of action is not known.

In the study with carbohydrate-sensitive individuals, men had higher average uric acid levels than women on all diets. This sex difference had been observed before and was expected. Uric acid levels in the women

did not exceed the normal range on any of the diets, although percentage increases in women were greater than in men.

Uric acid levels above 6.8 mg/ml for men and 6.3 mg/ml for women are considered abnormal. Men exceeded the 6.8 level 3 of the 6 weeks they were on the 18-percent sugar diet, and every week they were on the 33-percent sugar diet.

Screening Suggested

Reiser suggests that health officials may wish to consider a screening program to identify carbohydrate-sensitive individuals, in view of the risk of high sugar intake to these people. He said his suggestion is based on an accumulation of data, not only on data resulting from this study.

"Our research shows there are big differences in the way individuals respond to the sugar they eat," Reiser says. "There is no detectable response in some individuals. Yet others on a high-sugar diet develop extremely high levels of blood lipids (fats) and other signs generally associated with health risks.

"Testing could help identify individuals with higher than normal risk of developing disease such as atherosclerosis and diabetes—those whose likelihood of disease is heightened if they eat a lot of sugar. Informed of the risk, these persons might modify their sugar intake and reduce the risk."

Others on the SEA Carbohydrate Laboratory research team included Dr. Otho E. Michaelis IV, nutritionist Judith F. Hallfrisch, and dietitian Mary C. Bickard. Cooperating University of Maryland researchers included Dr. Elizabeth S. Prather, chairman of the University's Department of Food, Nutrition, and University Administration; and three biochemists, Dr. Mark Keeney, Karen D. Israel, and Ellen L. Bohn, of the Biochemistry Department.

Dr. Sheldon Reiser is located at the Beltsville Human Nutrition Research Center, Room 315, Building 307, BARC-East, Beltsville, MD 20705.—(By Andy Feeney, SEA, Beltsville, Md.)

The carbohydrate-sensitivity study required detailed data on dietary intake and metabolic responses. Nutritionist Judith Hallfrisch (left) of the Carbohydrate Nutrition Laboratory, and cooperating biochemist Ellen Bohn of the University of Maryland Biochemistry Department, study computer printouts of these diet records (0780X762-8).

Soils Affect Soybean Pollination

Pollination of soybeans and the amount of honey that bees produce from the crop may be affected by the soybean variety and fertility and texture of the soil.

That's part of a complex picture emerging from studies conducted by SEA and the state agricultural experiment stations in Wisconsin, Arkansas, and Missouri.

The latest study involved surveys of beekeepers and soybean growers of Mississippi Delta counties in Arkansas and Missouri. Excellent honey yields were obtained there year after year from bees foraging soybeans on heavy soils that had little or no acidity and high potassium levels and water-holding capacity.

Climate also may have a bearing on bees' work in soybean fields, says SEA entomologist Eric H. Erickson, Madison, Wis. In cooperative studies, he and University of Wisconsin entomologist G. Mallory Boush are taking an indepth look at how climate and soils may influence aroma and nectar of soybean flowers.

Soybeans are normally self-pollinated, but it is likely that bees will be the agents for cross pollination if hybrid soybeans become a reality. This research provides basic information that may be needed by plant breeders and commercial hybrid growers in the future.

Boush and Erickson will collect and analyze pollen, nectar, and aroma samples from soybeans grown in the Mississippi Delta. They will compare the nutritive value of pollen and nectar that bees obtain from soybean varieties of various maturity groups on various soils.

The researchers plan to eventually study the action of bees on soybeans grown in a unique, controlled-environment building called the biotron. In the biotron, they can control air and soil temperature, soil fertility, light and associated radiation, atmospheric moisture, air velocity, and sound. The biotron was built on the university campus with funds provided in the mid-1960's by the National Science Foundation, the National Institutes of Health, the Ford Foundation, and the State of Wisconsin.

Dr. Eric H. Erickson is located at SEA-USDA, Department of Entomology, University of Wisconsin, Madison, WI 53706.—(By Ben Hardin, SEA, Peoria, Ill.)

Infrared Thermometer Triggers Irrigation

Space age technology has caught up with irrigation management.

Irrigators, using an infrared "gun" can now take the temperature of a crop canopy—the foliage—and relate that temperature to surrounding air temperature, enabling the irrigator to determine when to irrigate a crop for maximum yields. The idea promotes irrigation efficiency and saves water and energy.

When soil moisture falls below the plant's needs, the plant becomes "stressed" and its temperature rises. When crop temperature exceeds that of the air for a certain length of time—which varies among different crops and soils—it's time to irrigate.

The concept of using the difference in the plant and air temperatures as a guide for efficient irrigation management has been under study for the past few years by SEA scientists at the U.S. Water Conservation Laboratory in Phoenix, Ariz.

When the study began, the researchers were using cumbersome infrared thermometers to measure canopy temperatures and regular thermometers to read air temperatures. They then computed the difference. The unwieldiness of that equipment prompted the scientists to write specifications for a gun that would make both readings and give a digital readout of the difference. Such a gun is now on the market. It weighs about 2 pounds, is operated by a trigger, and has rechargeable batteries.

The gun gives readings of the temperature difference between the crop and air surrounding the crop. When readings come up on the plus side, an irrigator knows it's nearing the time to apply water. Readings are made during the hottest part of the day, around 1:00 p.m. in Arizona.

SEA physicists Ray D. Jackson and Sherwood B. Idso and SEA soil scientist Robert J. Reginato, conceived the concept and are tuning it to finer, more precise efficiencies.

The trio has developed a system they call "stress-degree-days." Wheat, for instance, on Phoenix area soils has a tentative stress-degree-day classification of +10. If the differential reading on a wheat field one day is +2, the next day +3, and the following day +5, the total accumulation of +10 indicates that the crop needs water. Alfalfa and other crops have different stress-degree-day classifications.

Research entomologist Paul Pinter takes aim at cotton with an infrared thermometer. By measuring plant and air temperatures and computing the difference, the thermometer detects plant "stress," the plant's plea for water (PN-6811).

The stress-degree-day concept and the infrared gun are being compared to other irrigation treatments in the Wellton-Mohawk area of Arizona near Tacna, in cooperation with the Bureau of Reclamation.

One treatment uses Bureau of Reclamation irrigation guides and checks soil moisture with neutron moisture probes. Another treatment, based on a theory developed by Leonard J. Erie, SEA agricultural engineer, calls for irrigation after 65 percent of the available moisture in the top 3 feet of soil has been depleted. Four other plots are being irrigated when they accumulate +5, +10, +15, and +20 stress-degree-days.

Infrared temperatures of crops can be taken from ground level, high-flying aircraft, or space satellites, opening up countless uses for the concept.

Dr. Ray D. Jackson, Dr. Sherwood B. Idso, and Dr. Robert J. Reginato are located at the U.S. Water Conservation Laboratory, 4331 E. Broadway Road, Phoenix, AZ 85040.—(By Paul Dean, SEA, Oakland, Calif.)

New Process Converts Catfish Waste to Profit

Researchers have developed a silage process that converts catfish waste into a high-protein concentrate for use in animal feed. While food technologist Donald Freeman pours (left), chemical engineer William Bryan strains bones from liquified catfish waste (0280W209-11A).

A new process to convert catfish processing waste into high-quality byproducts has been developed by SEA scientists.

Waste generated by the rapidly growing catfish farming industry constitutes about 40 percent of the whole fish weight. Currently this waste is used in small quantities in cat food or is sent to rendering plants. Catfish farmers and processors realize little or no profit from either use, and disposal of this waste has become a serious problem.

Working at the SEA Southern Regional Research Center, New Orleans, chemical engineer William L. Bryan and food technologist Donald W. Freeman have developed a silage process that converts the waste into a high-protein concentrate (about 50 percent solids), bone meal, and catfish oil. The concentrate can be used directly as an animal feed supplement or pet food flavoring or it can be further dried to meal. The oil may have important industrial uses because it is more highly saturated than other fish oils.

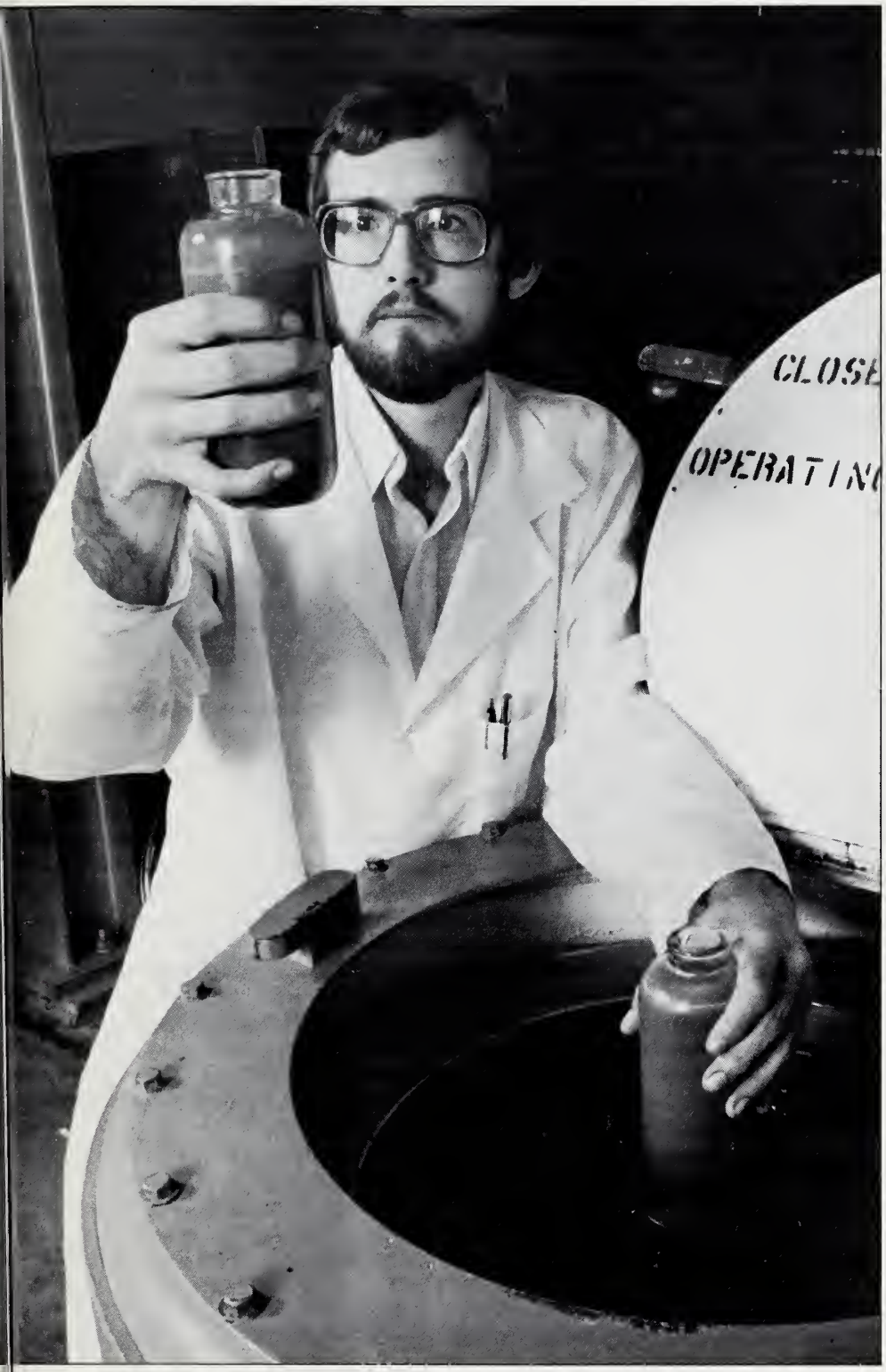
The new process involves liquifying the waste with natural enzymes activated by formic acid—which also inhibits microbial spoilage—screening out the bones, removing the oil by centrifuging, and evaporating most of the water.

The silage process offers several advantages over conventional rendering methods. Lower temperatures are used in processing silage, so the quality of the oil and the protein byproducts is higher. Concentrated silage contains no bones, so the dried meal contains about 80 percent protein. Energy requirements can be kept low by using a high-efficiency evaporator.

The catfish industry is growing at a rate of more than 25 percent per year, and large amounts of processing waste are being used uneconomically. In 1979, the industry processed about 42 million pounds of fresh catfish, about 17 million pounds of which was waste.

Farmers are now harvesting up to 4,000 pounds of catfish per acre of pond and selling the live fish for 60 to 65 cents per pound. As a result, more and more marginal land, particularly in Mississippi, Alabama, and Arkansas, is being put into catfish ponds in the expectation that the market for high quality catfish will continue to grow in the immediate future.

Donald W. Freeman is located at the SEA Southern Regional Research Center, 1100 Robert E. Lee Blvd., P.O. Box 19687, New Orleans, LA 70179. Dr. William L. Bryan is located at the SEA Southern Agricultural Research Center, Coastal Plain Experiment Station, Tifton, GA 31793. —(By Vernon Bourdette, SEA, New Orleans, La.)



Donald Freeman examines catfish oil, separated from waste by a centrifuge. Catfish oil is more saturated than other fish oils and may have important industrial uses (0280W210-15).

The Pacific Northwest fresh-fruit pear industry faces economic devastation from the pear psylla, a tiny insect related to aphids. Foreign ladybird beetles—imported from Japan, Australia, and Hong Kong—could rescue the industry from this plight.

Optimists say the Pacific Northwest pear industry will disappear within 10 years, while pessimists say within 5 years unless something is done to control the insect.

Robert Fye, a SEA entomologist at Yakima, Wash., has been testing the effectiveness of foreign ladybird beetles against pear psylla. He believes that releasing the beetles in a psylla-infested orchard might rapidly rid the orchard of the insect pest with no adverse effects on the fruit or the surrounding environment.

Pear psylla fly from orchard to orchard, feeding on sap from pear tree leaves. An excess in moisture and sugar, called honeydew, forms where the psylla feeds. This honeydew falls like a tiny rain on pears beneath the leaves, causing a browning or russeting of the fruit and rendering the pears unfit for the fresh-fruit market. Also, sustained infestations result in debilitation of the trees and poor production.

Insecticides currently being used against the pear psylla are not effective and sometimes cause secondary insect or mite problems. Fye believes that biological control of the pest may be possible by using the imported ladybird beetles, which are efficient predators of pear psylla.

The beetles being tested are *Harmonia conformis, Harmonia axyridis, Menochilus quadriplagiatus, Calvia 14-guttata,* and *Coccinella septempunctata L.*

Convinced of the beetles' promise as a biological control, Fye is now working to improve laboratory ladybug mass-rearing techniques so the insect can be stockpiled, then shipped to pear orchards in need.

Dr. Robert Fye is located at the SEA Yakima Agricultural Research Laboratory, 3706 W. Nob Hill Blvd., Yakima, WA 98801.—(By Lynn Yarris, SEA, Oakland, Calif.)

Waging War on a Peanut Pest

"We are introducing a new concept in pest management—the idea that a juvenile hormone analogue application and some species of parasites are not only compatible when used concurrently for insect pest management, but may even be mutually beneficial," says SEA entomologist David W. Hagstrum.

Hagstrum and University of Florida postdoctoral fellow David A. Nickle report that the application of methoprene, a juvenile hormone analogue (JHA), enhances the usefulness of the parasite *Bracon hebetor* against its host, the almond moth, a pest of stored peanuts. JHA's inhibit growth of undesirable insects.

The object is to do the least amount of harm to the useful parasites and inflict the most damage on the host insect, the almond moth.

"*B. hebetor* finds more of the almond moths in methoprene-treated peanuts than in untreated peanuts," says Hagstrum, "because the JHA prolongs this stage and the parasites have more time to find each host. The combination of methoprene treatment and the parasite shortens the feeding period of hosts. This reduces the damage to peanuts and the number of juvenilized hosts that eventually mature and reproduce."

JHA's have been considered as alternatives to broad spectrum insecticides because they do not harm the natural enemies of an insect pest. Generally, parasites developing within their insect host are protected from JHA's. However, other attributes of the JHA application may be even more important than this selective toxicity.

For example, by not killing almond moth larvae until the larval-pupal molting, the JHA insures that every host, even one destined to die, is suitable for the reproduction of many species of parasite. In fact, reproduction may actually be enhanced for parasites such as *B. hebetor* that attack the host during the last larval instar (stage between molts). The plus is that, for these parasites, even a JHA application which adversely affects an equal number of parasites and hosts would be beneficial to the parasites.

This last-instar almond moth larvae, almost ¾ inch long, is just about ready to pupate into an adult. After entering through a crack in the peanut shell, newly-hatched larvae begin to feed on the peanut kernel (0478X433-18A).

Researchers Hagstrum and Nickle applied methoprene—20 parts per million (ppm) in 80 milliters of acetone—to 5 of 10 samples of inshell peanuts. Twenty-five almond moth eggs were added twice weekly to each of the 10 samples for 3 weeks. Four weeks after all eggs were added, 10 *B. hebetor* females were introduced into each cage of samples. One week later, all peanut shells were opened and the numbers of hosts that had pupated or had been paralyzed or parasitized were recorded.

Overall, only 12.7 percent of hosts pupated in tests with JHA and parasites, while 45.7 percent pupated in tests with parasites alone. This reduced pupation resulted in a 60.8 percent increase in the number of larvae available to the parasites. In response to this increase in available hosts, the percentage of hosts parasitized by *B. hebetor* increased 58.3 percent, and the number only paralyzed increased 54.1 percent.

"We have suggested that the application of the JHA is compatible with the use of parasites. It is even advantageous to parasites as long as the development and reproduction of the parasites are not affected more severely than that of the hosts. In fact, more hosts will be available to many species of parasites after a JHA application than after an insecticide application, because many insecticides kill hosts immediately while the JHA does not kill hosts until the larval-pupal stage. Clearly, methoprene increases the availability of the almond moth host for the parasite, *B. hebetor,*" says Hagstrum.

Dr. David W. Hagstrum is with the SEA Insect Attractants, Behavior and Basic Biology Research Laboratory, P.O. Box 14565, Gainesville, FL 32604. Dr. David A. Nickle, formerly of the University of Florida's Department of Entomology and Nematology, is now with the SEA Systematics Entomology Laboratory, Museum of Natural History, 10th & Constitution, Washington, D.C. 20560.—(By Peggy Goodin, SEA, New Orleans, La.)

Almond Moth Recapture Rates Monitored

To evaluate the effectiveness of fumigants and new pest management techniques, scientists need accurate estimates of insect population levels.

The mark-release-recapture technique commonly used by entomologists to estimate insect density or trap efficiency has not been used often with stored-product insects.

SEA entomologist David W. Hagstrum and agricultural engineer James M. Stanley (retired) used the technique to evaluate the efficiency of suction traps in monitoring almond moth infestations in a peanut warehouse.

The population of the adult moth, *Ephestia cautella,* in a commercial seed peanut warehouse was sampled with a unidirectional suction trap during three storage seasons. In-shell "Florunner" peanuts were generally stored in this corrugated sheet-metal-clad, wooden frame warehouse from late August to February.

Once each week during the final year of study, almond moths marked with an internal dye or distinguished by rare alleles (genetic markings such as eye colors) were released. The recapture rates of released almond moths were determined from trap catches. After peanuts were stored, only males were released and the sex ratio, the female mating frequency, and the ratio of Indian meal moth to almond moth were determined.

Recapture rates the first day were 7 percent for females and 20 percent for males in an empty warehouse, and 31 percent for males in the stocked warehouse. Total 3-day recoveries were 11, 32, and 50 percent, respectively. Mating frequencies were generally between 46 and 75 percent. However, low-mating frequencies of 21 to 35 percent during periods of low population density could have been due to male trappings, the scientists say.

Comparison of release-recapture estimates for the native male with those for the native female populations indicated that the actual sex ratio was 1 to 1 although the captures were 67 percent male.

"Fewer females were captured than males," Hagstrum said, "probably because females spent time calling—releasing a sex pheromone—and ovipositing rather than flying, and flight was more difficult for heavy egg-laden females than for males. The efficiency of the suction trap did not change much through the 1-year sampling period. The traps were not baited with light or pheromone and probably caught only those moths blundering into them. Thus, the average male capture rate increased from 20 to 30 percent as the warehouse was stocked with peanuts and the head space was reduced," he says.

Adult Indian meal moths were present, but generally less abundant than adult almond moths, representing 30 to 50 percent of the catch during the first 5 weeks and then remaining below 20 percent.

Every 4 weeks the moth population doubled in the empty warehouse, with some scattered peanuts remaining. The population increased 37 times in the stocked warehouse. Since breeding was continuous, generations were overlapping.

"An ability to survive on limited resources and then multiply rapidly is probably an adaptive strategy common to many pest species," Hagstrum says.

Dr. David W. Hagstrum is located at the SEA Insect Attractants, Behavior and Basic Biology Research Laboratory, P.O. Box 14565, Gainesville, FL 32604.
—(By Peggy Goodin, SEA, New Orleans, La.)

By recapturing dye-marked insects, scientists can better evaluate the impact of pest management programs on moth populations. Entomologist David Hagstrum (left) examines almond moths caught in suction trap. Technician Shuichi Masuda places a new net on the trap, which will be suspended one meter above the peanuts (0378X274-9A).

Bacteria Help Recycle Waste Water

Natural processes in soil make it possible to recycle sewage water for irrigation and recreational lakes and to replenish groundwater at a fraction of the cost of chemical and other treatments.

For instance, in one of these processes, bacterial action can be "manipulated" to accelerate and improve removal of nitrogen, says SEA soil scientist Richard G. Gilbert.

In the recycling process, sewage water is channeled into basins where it percolates through several feet of soil, sand, or gravel to groundwater. From there, after it has been "purified" by bacteria, it can be pumped into irrigation canals, recreational lakes, or find its way to adjacent streams.

The main pollutants in sewage water are nitrogen, phosphorous, and intestinal viruses from human waste. Phosphorous adheres to clay soil particles in the upper few inches of the basin. Viruses also remain in the upper few inches, survive for a time, and die out.

Nitrogen, however, is in solution in the form of ammonium. In basins, bacteria convert ammonium to nitrate and unless removed (except by crop irrigation), nitrate can pollute lakes and streams and takes part in eutrophication—overenrichment—of natural water. Such overenrichment promotes algae growth that robs water of oxygen important to fish survival.

Two types of bacteria, each completing a separate process, remove nitrogen from water. One type, aerobic, (*Nitrosomonas* sp. and *Nitrobacter* sp.) converts ammonium to nitrate during the nitrification process. Another type, anaerobic, (*Pseudomonas* sp. and Bacillus sp.) breaks down nitrate to nitrous oxide and nitrogen gas, completing the denitrification process. The gases are dispersed harmlessly into the atmosphere.

By taking gas samples during denitrification and monitoring nitrous oxide given off bacterial action, scientists are able to estimate the amount of denitrification taking place. When levels of nitrous oxide begin subsiding, scientists add carbon in the form of alcohol or simple sugar to increase the denitrification rate. That is where the manipulation begins.

Carbon is necessary food for bacteria. When nitrate is present and nitrous oxide levels low, it is an indication that not enough carbon is present. Adding carbon—sugar or alcohol—keeps bacteria populations at a high level, accelerating nitrate conversion to aid recycling.

Dr. Richard G. Gilbert is located at the SEA U.S. Water Conservation Laboratory, 4331 E. Broadway Road, Phoenix, AZ 85040.—(By Paul Dean, SEA, Oakland, Calif.)

Grain Alcohol Awakens Dormant Weed Seeds

A dose of grain alcohol has proven to be a promising potion in attempts to force dormant weed seeds to germinate—research that could drastically reduce the crop weed problem.

Using ethanol, a SEA weed scientist has forced several annual weedy grasses and a few broadleaf weeds to germinate before their time. Although ethanol has not been tested in field conditions, it has stimulated a wider range of weed seeds than most other chemicals tested in the laboratory or the field, says Raymond B. Taylorson, SEA scientist at the Beltsville Agricultural Research Center in Maryland.

The earth's reservoir of dormant seeds is a mainstay of weed problems that plague farmers year after year. Some weed seeds can remain dormant in soil for as long as 100 years. Cultivated land usually contains about 10 million weed seeds per acre in the top 6 inches of soil. Some land may contain 100 million or more seeds.

"If most of these seeds could be forced to germinate at one time," Taylorson says, "they could be killed with herbicides before a crop was planted. And weed problems would be under control for many years to come."

Taylorson has had most success, 100 percent germination, with panicum—one of the principal weeds of corn and soybean acreage in the Northeast and Midwest. Witchgrass, crabgrass, and barnyardgrass seeds responded at better than 50 percent germination, a rate the scientist sees as the cutoff point for any seed eradication program to be cost effective.

Fall panicum and witchgrass germinated in complete darkness, but crabgrass and barnyardgrass needed red irradiation to induce germination. Wild oat and johnsongrass were impervious to ethanol and several other anesthetics Taylorson tested. So far, broadleaf germination has been under 50 percent.

Getting seeds to germinate in the absence of light is most important to any future weed-seed eradication program, Taylorson says. Many weed seeds require exposure to the red band of the spectrum which triggers a chemical called phytochrome to initiate

Above: Roused in unison from dormancy by an ethanol solution, these fall panicum seeds sprouted in total darkness. Successful germination of these seeds, examined by student laboratory aide Patti Powers, could lead to more timely germination of underground weed seeds for crop weed control (0180W081-25).

Upper right: Like any seed germinated in darkness, fall panicum sprouts do not develop their usual green pigment. This species, *Panicum dichotomiflorum*, has achieved 100 percent germination in the laboratory (0180W080-17).

the growth process. Those that do germinate each year are exposed to sunlight through cracks in the soil or are brought to the surface during cultivation. But the vast majority of weed seeds rest in the darkness of the soil.

Taylorson attributes his good results with fall panicum to "hitting on the right set of conditions at the start." He expects that further experimentation will produce similar results in other grasses and broadleaf weeds. The trick, he says, is to apply the right chemical in the correct dosage at the right time and temperature. Fall panicum responds best when incubated in the laboratory at 95 °F (35 °C) because it is a naturally late germinating grass, Taylorson explains.

There are substantial problems to overcome before ethanol or other anesthetics can become practical for weed control, he says. A method for keeping these highly volatile chemicals in the soil for at least 4 hours will have to be developed. And the 3 percent solution of ethanol that was workable in the lab translates to a costly 120 to 160 gallons of ethanol per acre (about 1100-1500 liters per hectare).

Taylorson noticed that anesthetics stimulated seeds to germinate while he was studying how they affect the properties of seed membranes. Exactly how anesthetics affect membranes is still a question, but the fact that they do is probably what triggers germination, he says. He noted that several SEA and state agricultural scientists are exploring other germination stimulants for practical weed-seed eradication methods.

Dr. Raymond B. Taylorson is located at the Beltsville Agricultural Research Center, Room 38, Building 001, BARC-West, Beltsville, MD 20705.—(By Judy McBride, SEA, Beltsville, Md.)

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Agrisearch Notes

Prussic Acid Source Found in Indiangrass. For 77 years, only plants of the genus *Sorghum* were known to contain dhurrin, the source of prussic acid poisoning in livestock. However, Nebraska scientists now have found dhurrin in indiangrass, *Sorghastrum nutans,* a warm-season perennial pasture grass of the eastern Great Plains.

Dhurrin yields hydrocyanic acid when broken down by an enzyme. Under some conditions, enough hydrocyanic acid may be released to be fatal to livestock grazing sorghum or sudangrass.

There are no reports of livestock loss resulting from grazing indiangrass, say University of Nebraska agronomist Francis A. Haskins, SEA geneticist Herman J. Gorz, and SEA agronomist Kenneth P. Vogel, at Lincoln. The scientists suggest this is because indiangrass is nearly always grazed in pastures containing a mixture of species. Pure stands of sorghum usually are grazed. Livestock also are seldom turned on pastures containing indiangrass until it is beyond the early-growth stage, when the highest hydrocyanic acid content would be expected.

The scientists tested 72 different grasses representing 39 species and 14 genera other than *Sorghum.* They found dhurrin only in indiangrass and a closely related *Sorghastrum* species. The assay procedure (*Agricultural Research,* July 1978, p. 14) determines hydrocyanic acid potential—the amount that will be released when the molecule is broken down into hydrocyanic acid, glucose, and *p*-hydroxybenzaldehyde.

The hydrocyanic acid potential indicated in indiangrass seedlings was in the range considered high when occurring in sorghum. Like sorghum, indiangrass' hydrocyanic acid potential was the highest and remained high longest in the first seedling leaves. Young tillers produced by established indiangrass plants also contained dhurrin.

Chromatographic analyses identified the compound in indiangrass as dhurrin. Also, observations of the nuclear magnetic resonance spectrum and the melting point supported the conclusion that the isolated compound was dhurrin and not taxiphyllin, a chemically similar compound found in some grasses.

Dr. Francis A. Haskins is located at 351 Keim Hall, Dr. Kenneth P. Vogel at 336 Keim Hall, and Dr. Herman J. Gorz at 362-A Plant Science Bldg., University of Nebraska, Lincoln, NE 68583. —(By Walter Martin, SEA Peoria, Ill.)

Coating Alfalfa Seed Ineffective. "We found that lime-coated alfalfa seed treated with a large range of Rhizobium bacteria concentrations, fungicides, and herbicides failed to improve seedling establishment, nodulation, or forage yields," says plant physiologist Gary H. Heichel.

Heichel evaluated alfalfa seed coatings under optimum establishment conditions for 1 year on two experimental areas, Rosemount and Becker, Minn., near the University of Minnesota.

At Rosemount, the seedlings were made in a clay loam soil containing about 80 pounds of nitrogen per acre. The Becker soil was a sandy loam with about 30 pounds of nitrogen per acre. The soil pH was 6.2 at Rosemount and 6.8 at Becker.

Heichel found a relationship between soil nitrogen and the number of nodules per plant and plot. The Becker plots produced nearly twice the nodulation as did the Rosemount seedlings, indicating that high soil nitrogen levels reduce nodulation. Similar results were observed in laboratory experiments. Seedling nodulation was not improved at either site by lime or inoculum coating.

Three herbicide treatments were tested. Herbicide coated seeds were planted by drilling and broadcast-incorporation. Uncoated seeds were also broadcast-incorporated following a pre-plant incorporation of herbicide.

"The preplant herbicide treatment was clearly superior to the seed coated with herbicide," Heichel says. "In fact, the coated plantings did no better than the control plantings with no herbicide treatment at all."

Test results in the Midwest have not shown an advantage for coated alfalfa seed in nonacid soils, Heichel says, adding that the results agree with their 1976 and 1977 findings (*Agricultural Research,* November 1978, p. 9).

Dr. Gary H. Heichel is located at the Department of Agronomy and Plant Genetics, University of Minnesota, 1509 Gortner Ave., St. Paul, MN 55108.—(By Ray Pierce, SEA, Peoria, Ill.)